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ABSTRACT

This curriculum supplement was designed to correlate directly with "A Guide to Curriculum Planning in Technology Education," published by the Wisconsin Department of Public Instruction. It is also a companion book to three other classroom activity compilations, one in each of the other three major systems of technology--manufacturing, communications, and construction. The entire set--the curriculum guide and the four activity books--follows the content organization given in the "Technology Education Content" fold-out chart in this guide. The activities are organized on the basis of how each supports one of the transportation concepts identified on the chart. Materials for this supplement were gathered from throughout Wisconsin and several other states, and most of them were developed by teachers. The seven sections of the guide include 16 activities grouped under the following topics: mediums (map reading); moving; energy conversion; propulsion systems; control (safety); guidance systems; and structural systems. Each activity consists of a description, resources needed, objectives, evaluation focus, procedures, information sheets illustrated with line drawings, and (sometimes) tests and answer sheets. (KC)

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Technology Education

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CLASSROOM ACTIVITIES IN TRANSPORTATION

CE 054 742

Wisconsin Department of Public Instruction
Herbert J. Grover, State Superintendent

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Foreword

Technology education is particularly well-suited to respond to our "Education for Employment" initiative and to facilitate career exploration for our students. The classroom activities in this resource relate directly to the technology of transportation, one of the four major systems identified in *A Guide to Curriculum Planning in Technology Education* as vital for helping students to understand the technological concepts and processes of the world around them. The other three systems are communications, construction, and manufacturing, and the Department of Public Instruction has prepared a compilation of relevant activities in each of those systems as well.

As teachers use the concepts contained in the guide and in these companion activity books, we hope they will develop new teaching directions that will enhance students' understanding of technology education and its impact on their present and future lives and careers. We must ensure the timeliness of this particular curriculum because we live in a world affected in every aspect by a variety of sophisticated, often baffling, technologies. In transportation, for example, we have jet propulsion; complex rocket propellants; smaller, lighter cars; and more sophisticated means of mass transit. It is possible to move goods and people faster, farther, and safer than in past decades. This possibility brings with it the potential for immense social change.

Technology education must take responsibility for imparting a basic understanding of the technological foundations of the many aspects of transportation. Materials, products, processes, problems, uses, and developments in the field of transportation must be an ongoing study, and timely occupational skills must be developed in our students.

These activities have been gathered to facilitate those ends. We encourage teachers, as they use these activities, to modify, expand, and reorganize them to fit individual classroom needs. These activities are intended to be subject to change and continuous improvement, so the Department of Public Instruction welcomes suggestions from users.

Herbert J. Grover
State Superintendent

Acknowledgments

It is not possible to list each teacher or agency that contributed to this collection of activities. Yet without the efforts of many in the field, this publication would not have been possible. We thank everyone that helped assemble this collection for graciously responding to our requests and for freely sharing their knowledge.

Special thanks are due to John Vanderhoof, former Department of Public Instruction (DPI) technology education consultant, for his part in gathering and clarifying the activities; to Dr. Leonard F. Sterry, program director for technology education majors, at the University of Wisconsin-Stout, who provided the original format and organized data collection from the field; and to Dr. Eunice Bethke, Chief, Consultation Section, DPI, for her facilitation and support.

Other DPI staff should also be acknowledged, especially Kathleen D. McCleave, editor of this supplement, for her efforts to find a consistent format and language for the activities and for her insistence on clarity and accuracy in the instructions. She was assisted with book design and graphics by Lisa Buckley. Additional thanks go to Barbara Sumwalt, technology education program assistant; Danni Jorenby, word processor/typesetter; and Kris Whitman, proofreader.

Introduction

This curriculum supplement, *Technology Education: Classroom Activities in Transportation*, was designed to correlate directly with *A Guide to Curriculum Planning in Technology Education* published by the Wisconsin Department of Public Instruction (DPI). It is also a companion book to three other classroom activity compilations, one in each of the other three major systems of technology—communications, construction, and manufacturing.

The entire set—the curriculum guide and the four activity books—follows the content organization given in the "Technology Education Content" fold-out chart. Thus, the activities in this particular book are organized on the basis of how each one supports one of the transportation concepts identified on the chart. An activity listed as "1A," for example, would have to do with the "Elements of Transportation," within the "Planning Base"; an activity listed as "3C" would relate to "Propulsion Systems" within the "Technical Systems" concept.

Materials for this supplement and the companion documents were gathered from throughout Wisconsin and several other states. Most of the activities were originally developed by individual instructors who are actively teaching portions of the technology education curriculum. Some were developed by state departments of education and by projects supported by those agencies. Still other materials were developed at universities. Since this was a process of *collection*, not *creation*, of materials, some content concepts are not covered at all, and others are represented by several activities. Also, as a collection of activities, this supplement does not contain a master plan for utilization and does not represent full courses. Instructors must identify major themes to be taught in support of these activities, such as the research and development process, system components, safety and tool/machine use, input-process-output model, and so on. In this regard, the content chart can be a useful tool for the development of courses consistent with the philosophy of technology education.

Due to the process used to solicit and assemble these activities, there are additional points that should be kept in mind while using this material.

- The three-hole punched format was selected to permit the publication of the best activities available now, while making it easy to revise and update the activities later. Teachers are encouraged to share new activities as they are developed, or to suggest refinements of the present ones.
- Some activities could be used to support more than one content concept. While an attempt was made to make the best match possible, in some cases an arbitrary decision was made as to placement. Teachers are encouraged to modify placement if it seems more appropriate for a local curriculum.
- Activities were developed in the field, not the office. As a result of individual teacher input,
  — there is not necessarily an activity supporting each concept in the content chart; but there may be more than one activity for some concepts; and
  — the level, language, and length of the activities varies widely.
- An "evaluation focus" has been suggested but individual teachers may wish to change, or add to, the evaluation process.
- Answer sheets are provided where they were provided to DPI or where they seemed necessary, but not all activities have them.
- Activities are usually addressed to one student, but group work is an appropriate modification, depending on an individual teacher's intent for the activity.
- In activities where safety hazards may exist, teachers should note "Cautions" throughout the activity and call them to the attention of students.

- Any of these materials may be copied for student use without restriction. The format was designed to facilitate reproduction in the field.
- The use of brand names (*Apple* computer, specified software) is not meant as a commercial endorsement.
- Some activities are self-contained, but most of them require lecture and/or demonstrations by the instructor.

Technology Education Content

This chart graphically depicts a content organization for the four major systems of technology—communications, construction, manufacturing, and transportation. Within each system, major instructional concepts are identified by number and letter and their specific subject matter is detailed.

The chart is the basis of the technology education program and content models presented in *A Guide to Curriculum Planning in Technology Education* (Madison, WI: Department of Public Instruction, 1988). Awareness and introductory level courses in technology education are drawn from the broad overview of the discipline presented in the first two vertical divisions of the chart. The detailed content necessary for exploratory and elective courses in each technological system comes from horizontal views across the last three divisions of the chart.

The chart is also the organizational basis for this supplemental classroom activity manual in transportation. Each activity is keyed to one of the instructional concepts identified on the chart. The curriculum planning guide and activity manuals in the other three technology systems—communications, construction, and manufacturing—are available from the Department of Public Instruction.

•Bas

TECHNOLOGY EDUCATION CONTENT*

Technology	**Communications**	1. Graphic	**A. Printing Systems and Processes** B. Photographic Systems and Processes **C. Industry Products** D. Industry Impacts	**Relief • Screen • Lithography • Gravure • Electrostatic • Ink Jet** Film Imaging • Electronic Imaging **Paper/NonPaper Materials • Consumable/Permanent Uses • Film • Print • Video** Economic • Political • Values/Attitudes • Environment • Aesthetic
		2. Electronic	**A. Telecommunications Systems and Processes** B. Hard-Wired Systems and Processes **C. Computer Systems and Processes** D. Industry Products **E. Industry Impacts**	**Radio • Radar • Television** Telephone • Telegraph • Public-Address Systems **Analog • Digital** Entertainment • Information/Data • Detection/Control • Computations • Data Exchange **Economics • Political • Values/Attitudes • Environment**
		3. Light	A. Interactive Systems and Processes **B. Passive Systems and Processes** C. Industry Products **D. Industry Impacts**	Laser • Fiber Optics **Signs • Flashing Signals** Entertainment • Information/Data • Detection **Economic • Political • Values/Attitudes • Environment**
		4. Acoustic	A. Sonic Detection Media and Processes **B. Storage and Retrieval Systems and Processes** C. Industry Products **D. Industry Impacts**	Gas • Liquid • Solid **Phonographs • Tape • Disks** Information/Data • Detection/Control • Entertainment **Economic • Political • Values/Attitudes • Environment**
	Construction	1. Planning Processes	**A. Research and Development** B. Marketing **C. Industrial Relations** D. Financing	**Initiating the Project • Developing the Project • Implementing** Analyzing the Market • Establishing Strategy • Promoting • Closing the Sale **Hiring • Training • Providing Benefits • Providing Career Options** Appraising Property • Estimating Costs • Funding • Documenting • Budgeting
		2. Production Processes	**A. Preparing the Site** B. Building the Structure **C. Installing Utility Systems** D. Enclosing the Structure (Rough Finishing) **E. Finishing the Structure (Fine Finishing)** F. Completing the Site **G. Servicing the Project**	**Clearing • Setting up Temporary Facilities • Surveying • Earthworking** Setting Foundations • Building the Major Structural Elements **Installing Permanent Utilities and Mechanical Plant • Providing Temporary Equipment** Preparing Materials • Handling Materials and Components • Assembling in Place **Prep. Subsurfaces • Prep. Materials • Handling Materials • Trimming • Removing Equip. & Debris** Removing Temporary Plant and Facilities • Landscaping • Building Features • Shaping the Finishing Earth • Removing Landscaping Equipment and Debris **Diagnosing/Troubleshooting • Repairing • Altering • Installing • Maintaining**
		3. Managerial Processes	A. Planning **B. Organizing** C. Directing **D. Controlling**	Formulating • Researching • Designing • Engineering **Structuring • Supplying • Scheduling • Routing • Storing** Coordinating • Assigning • Supervising • Inspecting • Authorizing **Monitoring • Reporting • Correcting**
	Manufacturing	1. Input (Planning Factors)	**A. Material** B. Human Resources **C. Capital** D. Finance **E. Knowledge** F. Energy	**Direct • Indirect** Managerial • Scientific/Technical • Office/Clerical • Worker/Operator **Plant • Equipment** Debt • Equity **Technological • Scientific • Humanities • Formal**
		2. Production Processes	**A. Extracting** B. Primary Processes **C. Secondary Processes**	**Drilling • Harvesting • Mining • Other** Thermal • Chemical • Mechanical • Electrical **Casting and Molding • Forming • Separating • Conditioning • Assembling • Finishing**
		3. Managerial Processes	A. Management Functions **B. Types of Managed Production** C. Managed Activities	Planning • Organizing • Actuating • Controlling **Custom • Intermittent • Continuous** Establishing the Organization • Designing the Product • Preparing to Produce • Producing • Delivering • Serving • Controlling the System
		4. Outputs	**A. Primary Outputs** B. Other Outputs	**Raw Materials • Industrial Goods • Finished Goods** Scrap • Pollution
	Transportation	1. Planning Base	**A. Elements of Transportation** B. Conquest of Time and Space **C. Foundation** D. People Systems **E. Material and Goods Systems** F. Mediums	**Human Mobility • Movement of Goods and People • Physical—(Natural and Human Produced)** **Inventions • Innovations** Personalized • Mass Transit **Natural Forms of Movement • Technologies of Transport** Land • Water • Air • Interrelated
		2. Transporting Processes	**A. Receiving** B. Holding/Storing **C. Loading** D. Moving **E. Unloading** F. Delivering	**People (Personalized and Mass Transit) • Materials/Goods (Bulk, Gross, Packaged)** People (Personalized and Mass Transit) • Materials/Goods (Bulk, Gross, Packaged) **Manual • Manually-Operated Mechanical • Mechanized • Hybrid** Terrestrial (Personalized and Mass Transit, Cargo–Bulk/Unit) • Marine • Atmospheric • Space **Automated/Mechanized • Manual/Mechanized • Manual • Hybrid** Means of Delivering to Final Destination
		3. Technical Systems	**A. Energy Sources** B. Energy Conversion **C. Propulsion** D. Suspension **E. Control** F. Guidance **G. Structural** H. Support	**Electrical • Chemical • Kinetic • Gravity • Mechanical • Magnetic • Solar • Nuclear** Internal Combustion • External Combustion • Hybrid Systems **Mech. Drive • Hydraulic Drive • Electric Drive • Vacuum • Gravity • Reaction • Storage Devices** Mechanical • Fluid • Magnetic **Velocity • Directional • Attitude • Altitude • Vehicular and System Control** Guideways • On-Board and External Devices • Interrelationship of Guidance and Control **Vehicular Design Considerations • Guideway Design Considerations • Support System Structures** Physical Facilities • Personnel • Regulatory Factors • Operational Systems
		4. Environmental Factors	**A. Human/Social** B. Economic/Service **C. Physical/Functional** D. Aesthetics **E. Interrelated**	**Safety • Human Values & Desires • Enhancement of Social, Recreational, Cultural Prog. & Facilities • Comfort/Convenience • Demand Responsiveness • Service for Handicapped & Disabled • Privacy** Transportation Costs • Access to Employment Opportunities • Efficiency **Effects on Land Use • Adaptable to Future Needs • Flexibility • Adaptable to Intermode Operation** General Appearance • Conservation of Natural Resources **Noise Level • Pollution Characteristics • Neighborhood Growth and Development • Accessibility**

*Based on taxonomies appearing in Thomas Wright and Leonard Sterry (co-directors). *Industry and Technology Education: A Guide for Curriculum Designers, Implementors, and Teachers.* Lansing, IL.: The Technical Foundation of America.

(1F) Mediums

Transportation

Map Reading, an activity supporting the Planning Base concept, is designed for approximately 5 class periods.

Resources Needed

Materials

Wisconsin state highway map
Wisconsin aeronautical chart
Both available from
Wisconsin Department of Transportation
Office of Public Affairs
4802 Sheboygan Ave., Room 103B
P.O. Box 7910
Madison, WI 53707
Kenosha city/county map

Note: This activity was developed using Kenosha, Wisconsin, as its focal point. The activity can be localized by using appropriate state and local maps/schedules and by adjusting the sample questions accordingly.

Objectives

The student will

learn to read highway and street maps;
discover the additional information (besides road routes) that the maps provide;
use maps as trip planning and budgeting tools; and
interpret and use an aeronautical chart.

Evaluation Focus

- ☒ Knowledge
- ☐ Awareness
- ☒ Problem Solving
- ☐ Machine/Tool Usage
- ☐ Attitude

Map Reading

Procedure

The automobile provides convenient and comfortable travel on nearly four million miles of roads and streets in the United States. Other modes of transportation depend upon highway movement of people or goods to collection points, such as airports or train depots. Because of the versatility of our highway system, the personal automobile is used for work, personal travel, and recreation. Buses also provide public transit in some rural areas, small cities, and large metropolitan areas.

The modern highway is designed to provide adequate traffic capacity to permit vehicles to move at legal speeds with safety and comfort in all conditions of weather. Even though vehicle design and fuel sources may change radically, there will still be a need for highway networks to serve our pattern of living and doing business.

This highway network does no good, however, unless you can get from one place to another safely and rapidly. When you have finished this unit, you will be able to read highway and aerial maps and should be able to find your way readily around the state and city.

1. Take the Wisconsin state highway map and unfold it carefully. (Remember how you took it apart because you will refold it at the end of the period.) Find the section that explains what the various symbols on the map mean and look at it. Note the different types of highways and how they are designated. Some are in heavy red lines, some are in thin double red lines, etc. Also, notice how some of the other symbols are used to indicate other things of importance. For instance, a public campground is identified by a small red tent. Airports are identified with small red airplanes, and hospitals are identified with a thick blue letter "H." There will be questions in this activity that ask you to find various landmarks or features on the map. If you are not sure how a certain feature is identified, refer back to this section.

2. Now find the "Index to Incorporated Villages and Cities." This index alphabetically lists all the major cities and villages in Wisconsin. Notice after the name of each city there is a column to the right with numbers and letters. They are called "coordinates." These coordinates can be used to help you find a city or town's location on the map.

3. Notice the numbers in the border on the right and left sides of the map. Also notice the letters in the border at the top and bottom sides of the map. These are also coordinates, and they correspond to the coordinates given for each city.

4. For example, find the city of Lake Geneva on the map by using the coordinates 11-H. Find the number 11 in the right border, and find the letter H in the bottom border. Draw an imaginary line left from the number 11 and up from the letter H. The city of Lake Geneva will be located very close to where the imaginary lines cross. See Figure 1.

Figure 1

5. Using the above information and the state map, answer *Question Set 1* on the Student Response Sheet.

6. Turn the Wisconsin highway map to the side with the mileage log. This mileage log lists the shortest distance between cities when using the state highway system.

7. To figure the distance between Chicago, Illinois, and Green Bay, Wisconsin, draw an imaginary line straight down from Chicago until you can draw an imaginary line straight over to Green Bay. Where the two lines meet, there is a rectangle with the number 204 inside it. It is 204 miles from Chicago to Green Bay. See Figure 2.

Note: The new 1987-1988 Wisconsin state map uses a different kind of table to compute intercity mileage. If you have the new map, use the directions printed by the new tables to get this figure.

BEAVER DAM	BELOIT	BLACK RIVER FALLS	CHICAGO, ILL.	CHIPPEWA FALLS	CRANDON	DARLINGTON	DODGEVILLE	DUBUQUE, IA.	EAGLE RIVER	EAU CLAIRE	ELLSWORTH	FLORENCE	FORT ATKINSON	FOND DU LAC	GREEN BAY	HAYWARD	HUDSON	HURLEY	JANESVILLE
76																			
130	175																		
147	97	264																	
191	234	61	328																
173	241	182	296	162															
104	64	148	161	309	289														
85	79	126	178	187	247	22													
133	94	147	184	208	268	40	48												
204	267	180	327	158	39	269	247	295											
160	223	60	314	14	177	198	176	198	172										
227	270	97	361	67	233	239	217	233	226	63									
205	270	224	313	210	83	307	289	336	64	222	275								
46	33	155	113	216	208	89	75	119	239	205	252	243							
32	103	148	148	202	149	136	117	166	180	192	239	171	70						
93	161	159	204	182	107	198	178	227	141	193	246	112	131	61					
261	323	161	414	97	187	298	277	298	135	111	122	190	306	283	261				
246	289	116	380	71	226	264	242	259	222	66	26	278	271	257	252	119			
252	309	204	398	188	108	314	292	341	76	182	208	130	290	245	207	86	205		
63	13	160	109	221	228	68	79	98	255	211	257	258	21	91	148	311	276	296	

Figure 2

8. Use the mileage log on the state map to help you answer *Question Set 2* on the Student Response Sheet.

9. The Rhinelander area is a popular Wisconsin vacation spot in the summer. Imagine you are planning your vacation to this area. Select the shortest route from Kenosha, using only highways shown on the map. Starting at Kenosha, take Highway 50 to I-94 and plan the rest of the route to Fond du Lac. On the basis of this exercise, answer *Question Set 3* on the Student Response Sheet.

10. City maps also can provide a great deal of information. Study the map of the city of Kenosha and answer *Question Set 4* on the Student Response Sheet.

Travel by air has become increasingly popular over the past 20 years. Aviation provides access to practically anywhere. While commercial airlines carry many people, the majority of flights in the United States are made by private aircraft and private pilots. Private aircraft go to more locations and make more trips than public air transportation, but they carry fewer persons per flight.

There are more than 187,000 civil aircraft in the United States. Their activities include recreation, crop dusting, pipeline and power line patrol, border patrol, highway surveillance, traffic management, mapping, photography, medical emergency, rescue, etc.

11. Unfold the Wisconsin aeronautical chart and turn to the box with the aeronautical symbols. When you have studied it, answer *Question Set 5* on the Student Response Sheet.

Map Reading

Name _____

Class/Period _____

Question Set 1

1. What are the coordinates for the city of Rhinelander? _____
2. What are the coordinates for the city of Black River Falls? _____
3. What kind of highway lies between Solon Springs and Minong? _____
4. What is the number of this highway? _____
5. What is the distance between Marshfield and Spencer? _____
6. Is there a forest ranger station at Spring Green? _____
7. Does Eagle River have an airport? _____
8. What is the distance between Marshfield and Stevens Point? _____
9. What kind of wayside is located between the two? _____
10. If you were in Thorp and needed a hospital, where would you find the nearest one? _____
11. Is there a university or college at Prairie Du Chien? _____
12. In what county is Oshkosh located? _____
13. What is the number of the Wisconsin highway known as the Great River Road? _____

Question Set 2

1. What do the numbers in the rectangle represent? _____
2. What is the distance between the cities of Ashland and Wisconsin Rapids? _____
3. What is the distance between Kenosha and Madison? _____

4. What is the distance between Kenosha and Milwaukee? _____

5. What is the distance from Milwaukee to Chicago, Illinois? _____

6. What is the distance between Alma and Antigo? _____

7. What is the distance between Wisconsin Dells and Wisconsin Rapids? _____

8. How many miles is it from Kenosha to Monroe? _____

Use the detailed city maps or the state map to help you answer the following questions.

9. Name the largest lake entirely within the borders of Wisconsin? _____

10. What is the main north/south street in the city of Superior? _____

11. What two highways border the southeast corner of the Kenosha airport? _____

_____

12. List the four streets that border Mitchell Field in Milwaukee (**Note:** "10.6" is a mileage designation and is not the name of a street.) _____

_____

_____

_____

13. What are the two main highways between Kenosha and Racine? _____

_____

14. What kind of highway is Highway 51? (**Note:** Use the Madison city map.) _____

15. What are the names of the two lakes located on either side of the state Capitol in Madison? _____

_____

16. Two rivers separate Minnesota from Wisconsin. What are their names? (Use the state map.) _____

_____

17. What is the name of the national forest that is located northwest of Medford? _____

Use the "State Park, Forest, and Trail Information" chart to answer the following questions.

18. Locate Rib Mountain State Park. What city is nearby? _____

19. Is camping available at Governor Dodge State Park? _____

20. Are there electric outlets at Aztalan State Park? _____

21. Is there family camping at Bong Recreation Area? _____

22. Is camping available at Rocky Arbor State Park? _____

23. What facilities are not available at Governor Dodge State Park? _____

_____

_____

Question Set 3

1. After leaving I-94, list the highways you would take to arrive at Rhinelander? _____

_____

_____

2. What is the mileage from Kenosha to Rhinelander? _____

3. You leave Kenosha at 8:00 a.m., driving at 55 miles per hour. The logical place to stop for lunch at noon would be? _____

4. Your car has an 18-gallon gas tank. It gets 14 miles per gallon (mpg) on the average. How many miles could you expect to drive if you start out with a full tank and drive until the tank is empty? _____

5. You don't want to drive until you run out of gas, but you only want to stop once for gas while you still have some in the tank. Where would the logical place be to fill up your tank? How far would it be from Kenosha? _____

_____

6. If you allowed 45 minutes for lunch and 15 minutes to fill your gas tank, about what time would you get to Rhinelander if you did not exceed 55 mph? _____

7. How many gallons of gasoline would you need to drive from Kenosha to Rhinelander? (Total miles driven divided by miles per gallon equals total gallons used.) _____

8. If gasoline costs $1.21.9 per gallon, what will gasoline for the trip cost? (Total gallons used multiplied by price per gallon equals total cost.) _____

9. A United States gallon contains 3.785 liters. How many liters of gasoline would you need for the trip? (Gallons times 3.785 liters equals total liters.) _____

Question Set 4 (Use Kenosha city map—optional.)

1. What is the symbol for city parks? _____

2. What is the name of the park with map coordinates of 4-L? _____

3. What is the symbol for schools? _____

4. What are the map coordinates for Bullen Junior High School? _____

5. How many hospitals are there in Kenosha? _____

6. If you were at the intersection of 30th Avenue and 35th Street and wanted to drive to the nearest hospital, which one would you drive to? _____

7. What would be the most direct way to get to the hospital? Name the street you would take. _____

8. Turn your map over to the map of Kenosha County. What small community is located at the map coordinates of 4-E? _____

9. What small community is located at the intersection of Highway 50 and County Highway D? _____

10. Bong Recreation Area is named after Major Richard Bong, a World War II hero from Wisconsin. What two highways run through the Bong Recreation Area? _____

Question Set 5 (Use aeronautical chart.)

1. Going directly from the Kenosha airport to the Rhinelander airport, what is the mileage? (Give statute miles—see mileage scale on bottom of map.) _____

2. If your airplane flies 120 mph and there is no wind, how long would it take to get to Rhinelander from Kenosha? (Total miles divided by miles per hour equals time it would take to get there.) _____

3. Does the airport at Eau Claire have a control tower? _____

4. One hundred fifty statute miles is approximately how many nautical miles? _____

5. Does the Kenosha airport have hard-surfaced runways? _____

6. How do you know whether an airport has a rotating beacon? _____

7. If aviation fuel costs $1.80 per gallon and your airplane burns 8.5 gallons per hour, how much would fuel for the flight to Rhinelander cost? _____

8. Does the Green Bay airport have hard-surfaced runways? _____

9. What is the symbol for a heliport? (A heliport is the landing area used by helicopters.) _____

Map Reading

Question Set 1

1. 4-F
2. 7-D
3. U.S. highway
4. 53
5. 9 miles
6. Yes
7. Yes
8. 35 miles
9. With facilities
10. Stanley
11. No
12. Winnebago
13. 35

Question Set 2

1. Miles
2. 187 miles
3. 104 miles
4. 37 miles
5. 93 miles
6. 204 miles
7. 56 miles
8. 101 miles
9. Winnebago
10. Tower
11. 158
    192
12. College or ZZ
    Pennsylvania
    Howel
    Layton
13. 31
    32
14. U.S.
15. Mendota
    Monona
16. Mississippi
    St. Croix

Question Set 2 (cont.)

17. Chequamegon
18. Wausau
19. Yes
20. No
21. No
22. Yes
23. Nature center, ice age unit, and bicycling

Question Set 3

1. 41
   45
   8
2. 265
3. Antigo
4. 252
5. Antigo
   219 miles
6. 2:00 p.m.
7. 19
8. $23.16
9. 71.9 liters

Question Set 4

1. Blue # in circle
2. Anderson
3. Red # in circle
4. 3D
5. 2
6. St. Catherine's
7. 35th Street
8. Silver Lake or Camp Lake
9. Bristol
10. 75
    142

Question Set 5

1. 196
2. 1.5 hours
3. Yes
4. 130
5. Yes

Question Set 5 (cont.)

6. Star symbol
7. $22.95
8. Yes
9. H

(2D) Moving

Transportation

Barge Efficiency, an activity supporting the Transporting Processes concept, is designed for approximately 5 class periods.

Resources Needed

Equipment
- Vacuum forming machine
- Equipment to make molds
- Spring scale
- Stop watch
- Water tank
- Balance beam scale

Material
- Plastic

Demonstration
- Vacuum former

Objectives

The student will
- use a vacuum forming machine;
- design and form a barge hull; and
- test the efficiency of the design.

Evaluation Focus

- ☐ Knowledge
- ☐ Awareness
- ☒ Problem Solving
- ☒ Machine/Tool Usage
- ☐ Attitude

Barge Efficiency

Procedure

1. After seeing a demonstration on how to create a plastic barge hull using a vacuum former, decide upon a design for your barge hull.

2. Vacuum form a barge hull of your design.

> **▶ Caution**
>
> The vacuum former should be operated only with your instructor's permission and/or presence.
>
> Do not touch the heating element with your bare hands. It will be hot enough to cause severe burns.

3. After the plastic has cooled, trim the excess plastic from the edge with shears. Leave a small tab on the front.

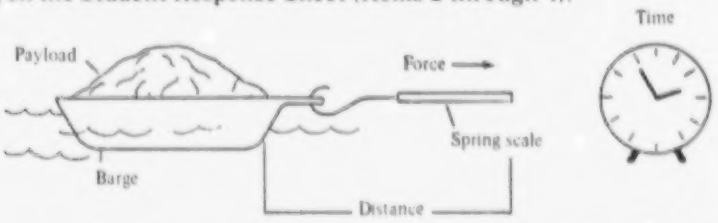
4. Put a hole into the tab, and attach the spring scale.

5. Place a predetermined payload in your barge and weigh the barge and load on the balance beam. Record the weight on the Student Response Sheet (Item 1).

6. Fill a tank with water and float the loaded barge. Attach a spring scale to the barge bow.

7. Measure the longest distance the tub will allow and, using the spring scale as a tow, pull the loaded barge the marked distance through the water .

8. Time how long it takes with a stopwatch, and record the distance, time, and scale reading on the Student Response Sheet (Items 2 through 4).



9. Subtract the loaded barge weight from the spring scale reading in order to determine the amount of relative drag. Record this amount on the Student Response Sheet (Item 5).

10. Using the formula power = $\frac{\text{force x distance}}{\text{time}}$, where *force* is the spring scale reading, *distance* is the distance traveled, and *time* is the elapsed time, calculate the power necessary to move the loaded barge and record your results on the Student Response Sheet (Item 6).

11. Based upon your observations, write a conclusion statement about this activity on the Student Response Sheet (Item 7).

Barge Efficiency

Name _____

Class/Period _____

1. Loaded barge weight

2. Distance traveled

3. Elapsed time

4. Spring scale reading

5. Drag

6. Power

7. Statement of conclusions

(2D) Moving

Transportation

Bicycle Systems, an activity supporting the Transporting Processes concept, is designed for approximately 13 to 17 class periods.

Resources Needed

Equipment

Bicycle
Overhead projector
Assorted bicycle repair tools
Videotape monitor

Materials

Transparencies
Videotapes on bicycle repair (often available from local dealers and manufacturers)

Suggested Reference

How to Fix Your Bicycle (available from Schwinn dealers)

Note: This activity has five separate parts. Each part requires additional specific resources, which will be identified separately. The activities require frequent lectures/demonstrations by the instructor.

Objectives

The student will

explore the work of the bicycle repair profession;
develop basic skills in the proper use of common tools, machines, and processes associated with bicycles;
complete basic bicycle maintenance tasks; and
develop an understanding of the bicycle industry and its place in our culture.

Note: More specific objectives are given in each separate part of the activity.

Evaluation Focus

☒ Knowledge	☒ Problem Solving	☐ Attitude
☐ Awareness	☒ Machine/Tool Usage	

Bicycle Systems

Tube and Tire Repair—Cold Patch (1 day)

Resources Needed

Schwinn tube and tire handouts
Transparencies of tube and tire assembly
Tire irons
Tire pump
Pressure gauge
Water tank
Wheel with tube and tire
Cold patch
Tire talc
Chalk

Specific Objectives

The student will
identify tube and tire components;
paraphrase function of each component;
list tube and tire repair procedures;
identify various types of punctures and failures; and
safely and correctly use hand tools associated with tube and tire repair in a lab situation.

Procedure

1. View lecture, demonstration, or videotape on the parts of a tube and tire and their functions.

2. Read pages 26 and 27 of *How to Fix Your Bicycle*.

3. Read Schwinn tube and tire handout.

4. Watch demonstration or videotape on how to remove tube and tire from rim.

5. Watch demonstration or videotape on how to inspect, repair, and test patch.

6. Watch demonstration or videotape on how to mount tube and tire on rim.

Rear Derailleur (3 days)

Resources Needed

Damaged real derailleur
Functional derailleurs mounted on trainers

Specific Objectives

The student will
know how to adjust the rear derailleur;
know when parts need replacement due to wear or damage;
be able to replace components;
know the names and functions of derailleur components; and
be able to adjust rear derailleur mounted on trainer.

Procedure

1. Attend lecture and discussion on rear derailleur.

2. View demonstration on how to identify worn or damaged derailleur.

3. Replace worn parts on sample derailleurs.

4. Adjust rear derailleur.

5. Read pages 90 to 104 of *How to Fix Your Bicycle*.

Five- and Ten-Speed Gear Train (1 day)

Resources needed
Gear train components

Specific Objectives

The student will
know the names and functions of all components of a bicycle gear train system;
know how to adjust the different components of a gear train system;
know when parts need replacement due to wear or damage;
be able to replace parts needing replacement; and
be able to recognize the different levels of component quality.

Procedure

1. Attend lecture and discussion on gear train components.

2. Read pages 90 to 104 of *How to Fix Your Bicycle*.

Side-Pull Brakes and Controls (4 days)

Resources Needed

Third-hand tool
Cable cutter
Caliper wrench set
6" adjustable wrench
Wheel bearing grease
Spray lubricant
Wiping cloth
Parts cleaner solvent

Specific Objectives

The student will
know the names and functions of all components in a side-pull brake system;
know how to adjust the system;
know when parts need replacement due to wear or damage;
be able to replace components; and
be able to complete manufacturer's periodic service checks.

Procedure

1. Attend lecture and discussion on side-pull brakes and controls.
2. View demonstration on how to identify worn or damaged parts.
3. Replace worn or damaged parts.
4. Complete manufacturer's periodic service checks.
5. Adjust side-pull brake components and controls.
6. Disassemble, service, and assemble side-pull brakes and controls.
7. Read pages 23 and 24 of *How to Fix Your Bicycle*.

Center-Pull Brakes and Controls (4 days)

Resources Needed

Same as in side-pull brakes activity above

Specific Objectives

The student will
know the names and functions of all components in a center-pull brake system;
know how to adjust the system;
know when parts need replacement due to wear and damage; and
be able to complete manufacturer's periodic service checks.

Procedure

1. Attend lecture and discussion on center-pull brakes and controls.
2. View demonstration on how to identify worn or damaged parts.
3. Replace worn or damaged parts.
4. Complete manufacturer's periodic service checks.
5. Adjust center-pull brake components and controls.
6. Disassemble, service, and assemble center-pull brakes and controls.
7. Read pages 23 and 24 of *How to Fix Your Bicycle*.

(2D) Moving

Transportation

Building a Model Aircraft, an activity supporting the Transporting Processes concept, is designed for approximately 2 class periods.

Resources Needed

Equipment

Delta Dart II "Amazer" model aircraft kits, available from
Delta Dart Midwest Products Co., Inc.
400 South Indiana Street
P. O. Box 564
Hobart, IN 45342
Phone: (219) 942-1134
or another similar product

Objectives

The student will

become familiar with basic aeronautical concepts, terminologies, and related vocabulary;
work with a parner(s) toward a common goal (successfully building a flying model aircraft); and
observe and evaluate the quality of the aircraft in a series of test flights.

Evaluation Focus

☒ Knowledge
☐ Awareness
☒ Problem Solving
☐ Machine/Tool Usage
☐ Attitude

Building a Model Aircraft

Procedure

Aviation plays a major role in today's world. It ranks as one of this nation's largest employers and serves as one of the nation's more important modes of transporting people and materials.

In order to accomplish its purpose, the airplane must move efficiently through the atmosphere. By completing this activity, you will gain basic insights into why and how the airplane is able to remain airborn.

1. Flight has a vocabulary of its own. Some of the more important terms you should know are listed. Learn these terms and keep them in mind as you construct your aircraft.

Forces

Drag: the backward-acting force provided by inertia and wind resistance
Lift: the force that opposes gravity; the upward-acting force
Thrust: the forward-acting force provided by the propeller
Weight or gravity: the downward-acting force

Axis

Lateral axis: imaginary line from wing tip to wing tip
Longitudinal axis: imaginary line extending through the body (fuselage) of the plane from nose to tail
Vertical axis: imaginary line extending up and down through the center of gravity of the plane

Miscellaneous

Airfoil: a shape that uses the Bernoulli Principle (see below) to provide lift (for example, an airplane wing)
Chord: an imaginary straight line running between the leading edge and the trailing edge of the airfoil
Dihedral: the angle at which the right and left wings are inclined upward
Leading edge: the forward, rounded edge of an airfoil
Trailing edge: the aft, narrow, and tapered edge of an airfoil

Movement

Pitch: movement of plane around the lateral axis (controlled by the rudder)
Roll: movement around the longitudinal axis (controlled by the ailerons)
Yaw: movement around the vertical axis (controlled by the rudder)

Principles

Bernoulli Principle: In the flowing liquid, (air) pressure decreases as the speed of the fluid increases.

Newton's First Law of Motion: Objects in motion tend to remain in motion unless acted upon by another force.

Newton's Second Law of Motion: The acceleration of an object is proportional to the force applied to it.

2. Refer to and follow precisely the direction sheets for building and flying your aircraft model.

3. Test fly your aircraft.

(2D) Moving

Transportation

Inland Waterways, an activity supporting the Transporting Processes concept, is designed for approximately 2 class periods.

Resources Needed

Materials

Maps of United States, identifying major inland waterways

Objectives

The student will

understand the difference between inland waterways and maritime waters;
see the relationship between the kind of waterway being used and the type of vessel that is appropriate; and
label major inland waterways on a blank map of the United States.

Evaluation Focus

☒ Knowledge	☐ Problem Solving	☒ Attitude
☒ Awareness	☐ Machine/Tool Usage	

Inland Waterways

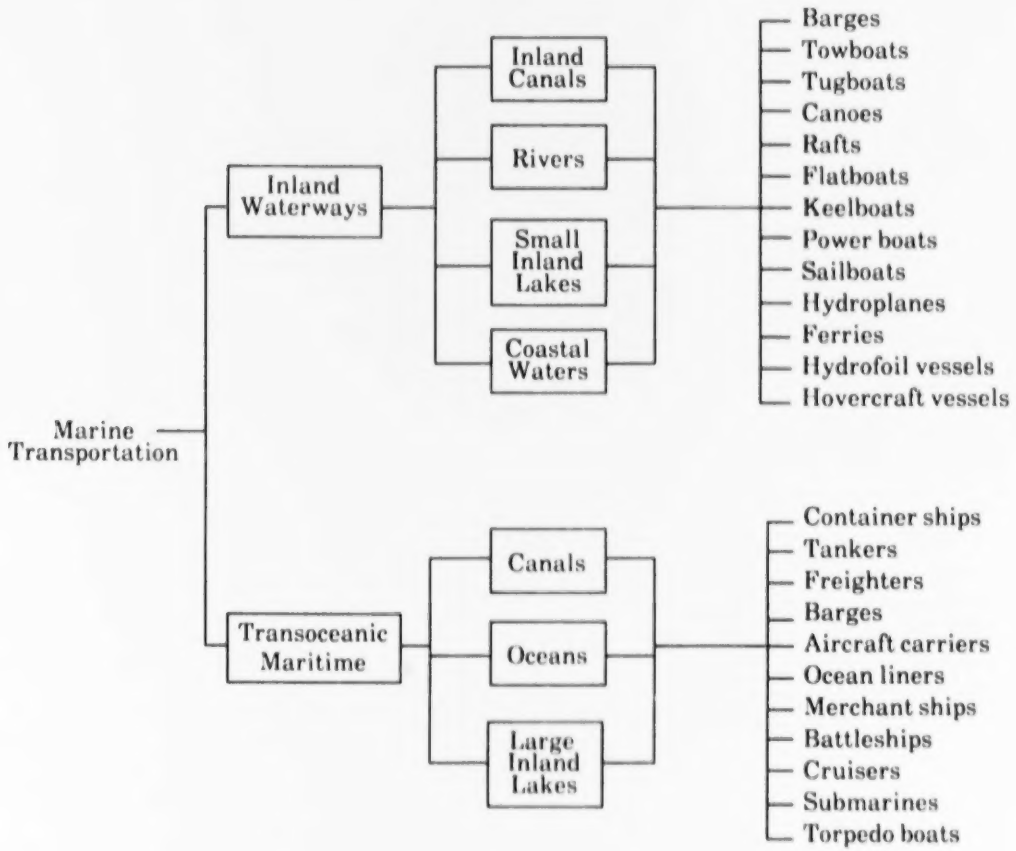
Procedure

Marine transportation takes place on either inland waterways or as transoceanic or maritime travel. The type of boat used usually depends upon the kind of waterway being traveled.

Inland waterways include canals, rivers, small domestic lakes, and coastal waters. The canals and rivers often limit vehicular type due to their restrictive width. Domestic lakes and coastal waters require more guidance than do the canals and rivers, which need little or no guidance. (It's hard to get lost on a river.)

Transoceanic or maritime waterways include large, inland lakes and the oceans and seas. These are "open waterways," which require sophisticated guidance systems.

The types of vessels most commonly found on the various waterways are shown schematically.



Inland Waterways

Name _____

Class/Period _____

On the blank map of the continental United States, label the major inland waterways, using different colored pencils for each type.

(2D) Moving

Transportation

Model River Barge, an activity supporting the Transporting Processes concept, is designed for approximately 3 class periods.

Resources Needed

Materials

Various construction materials

Suggested References

DeOld, Alan R. *Transportation*. Worcester, MA: Davis Publications, 1986.

DeVore, Paul. *Exploring Technology*. Worcester, MA: Davis Publications, 1984.

Objectives

The student will

understand and apply the concepts of floatation and displacement; and design and construct a model river barge according to specifications.

Evaluation Focus

☒ Knowledge	☒ Problem Solving	☐ Attitude
☐ Awareness	☒ Machine/Tool Usage	

Model River Barge

Procedure

Water comprises approximately 70% of the earth's surface. Before terrestrial transportation had been established, the waterways made it possible to transport heavy loads over great distances. Indeed water was, and still is, an important medium of transportation.

The basics of water transportation have remained the same since its beginning. The concepts of displacement and flotation still play an important role in marine vehicle design. Technology, however, has altered many of the "technical" systems, such as propulsion, control, guidance, and structural material. For example, early usage of wind for propulsion developed into steam engines, which further developed into nuclear power. Another major technical evolution included the structural changes from wood to iron to steel to special alloy hulls. Additionally, ships now use satellites for guidance, which is quite a change from early attempts to use a sextant. More recent developments in marine transportation technology have been efforts to reduce the drag of crafts by lifting the hull to skim the surface of the water or to suspend the craft on a film of air. A hydrofoil craft has several small wings (foils) that protrude into the water. As the craft gains speed, the foils create *lift*, which in turn raises the hull out of the water thus reducing surface drag. In the hovercraft, the vessel is supported by a cushion of air that lifts it out of the water. These two vehicles are normally propelled by water-jet propulsion or air propulsion systems.

The marine transportation systems have a bright future because of their adaptiveness and ability to coordinate with other modes of transportation. The systems are still widely used for shipping many types of commodities, particularly such bulk commodities as grains, coal, ore, and petroleum.

Design Problem

You are to design and construct a scale model of a river barge. The specifications and requirements are listed below.

1. Use a scale of 1/2" equals 1'.
2. Channel depth will be between 15' and 20', to scale.
3. The completed barge must hold a minimum of nine pounds of cargo.
4. You may use any materials or combinations in your construction.
5. A preliminary scaled drawing must be completed prior to construction.

(2D) Moving

Transportation

Pipelines, an activity supporting the Transporting Processes concept, is designed for approximately 3 class periods.

Resources Needed

Equipment

Pipeline lab station (set up in advance) using:

3/4" I.D. clear tubing	25'
3/8" I. D. clear tubing	5' sections (4)
3/4" O.D. brass union T	4
3/8" petcocks (spring-loaded gate type)	5
U.S. gauge 0-30 PSI bourdon-tube-type gauges	4
No. 72 hose clamps	12
No. 84 hose clamps	4
Armstrong model SF-15 circulating pumps with 1/4 horsepower at 2,500 RPM (or comparable pumps)	2
3/4" O.D. flush-fill tee	

Materials

Ethylene glycol (antifreeze)
Water solution
10W motor oil
Solution of student's choice (approved by instructor)
Turpentine (and/or other appropriate solvents)

Objectives

The student will

gain further insight into the pipeline industry and how it affects our society;
understand the various commodities that can be shipped by pipeline;
understand how various terrain affects different types of goods and the piping pressures required to transport them; and
gain insight into future aspects and uses of the pipeline for transporting goods.

Evaluation Focus

☒ Knowledge	☐ Problem Solving	☒ Attitude
☐ Awareness	☐ Machine/Tool Usage	

Pipelines

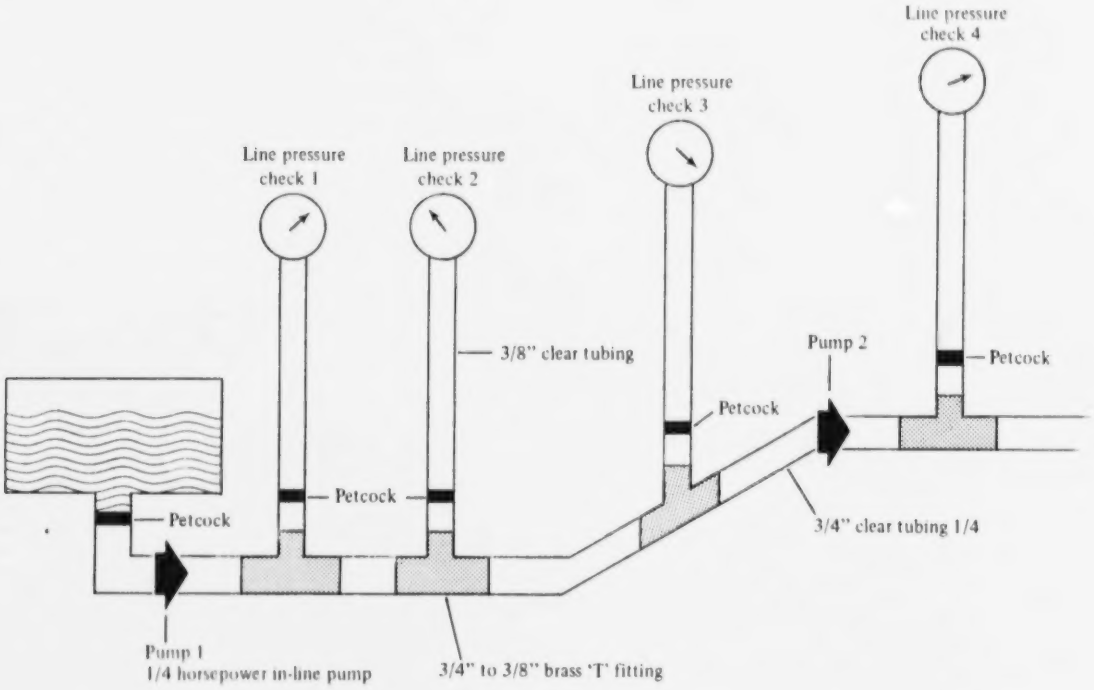
Procedure

The advent of the Alaskan Pipeline in the 1970s gave America a dramatic example of how various fuels can be transported efficiently from one point to another through the use of a pipeline. When we think of a pipeline, usually we think of some above-ground pipe structure that spans miles and miles carrying various commodities, such as oil, coal slurry, natural gas, and the like. Yet, there are many forms of pipelines that we never consider even though we use them every day. Sewer and water hookups to our homes and businesses, which allow us to have fresh water at the turn of a handle, and natural gas lines for home heating and cooking are examples.

In fact, in 1980 more than 23% of all oil products were transported by pipelines. Pipelines continue to grow in popularity for shipping many liquid and solid goods because of the relative low cost for shipping mass amounts of a commodity.

Through this unit, you will gain a better understanding of the growing pipeline industry and of the types of goods that can be shipped by pipeline. Using the pipeline lab station, you will have a chance to see firsthand how liquid viscosity and pump pressure affect the transporting of various solutions.

The setup of the pipeline lab station will be as shown. It can be mounted on any open wall space.



The two in-line pumps demonstrate how different locations for pumping stations affect the different line pressures over different terrain. You will be able to run either one or both of the pumps simultaneously. Through the use of the petcocks, you can shut off separate extending lines and see how that affects the next line pressure. Using four different lines off the main line, with a petcock to shut off each one, provides 72 possible combinations of line pressures for each fluid.

The pumps are capable of pumping substances of different viscosity, which will show you that different pressures are needed to transport various commodities.

Test a variety of solutions, checking several pressure readings for each. Some of the fluids tested will be:

ethylene glycol (antifreeze),
water solution,
10W motor oil, and an
instructor-approved solution of your choice.

Use the chart on the Student Response Sheet to record your test results. Use one or both motors as indicated and restrict fluid flow as indicated, and complete the chart. Then answer the questions following the chart. **Note:** Each fluid is introduced into the pipeline lab station through the fluid reservoir. You will have to clean the lines between each fluid with an appropriate solvent, such as water after antifreeze or turpentine after motor oil.

Pipelines

Name _____

Class/Period _____

Chart of Results

Complete the following chart, using one or both motors as indicated and restricting fluid flow with the petcocks as indicated

	Motor A				Motor B				Both A and B			
	Line 1	Line 2	Line 3	Line 4	Line 1	Line 2	Line 3	Line 4	Line 1	Line 2	Line 3	Line 4
Petcocks	All Open	1 & 2 Open	Only 3 Open	Only 4 Open	All Open	1 & 2 Open	1, 2, 3 Open	Only 4 Open	All Open	1, 2, 3 Open	Only 3 Open	All Open
Fluid A												
Fluid B												
Fluid C												
Fluid D												

1. How will this information help an engineer determine which fluid to use in a given set of circumstances?

2. Which fluid would give the best overall performance if you were going to pump a very heavy sludge through a level pipeline?

Building a Steam Turbine Engine, an activity supporting the Technical Systems concept, is designed for approximately 2 class periods.

Resources Needed

Equipment

Propane torch
Ring stand
Tin snips
Standard hand tools

Materials

Metal cans with removable tops (paint cans)
Tin can tops (from coffee cans, juice cans, etc.)
Scrap lumber

Suggested References

Bohn, Ralph C., and Angus J. MacDonald. *Power: Mechanics of Energy Control*. Bloomington, IL: McKnight Publishing Co., 1983.

Duffy, Joseph W. *Power: Prime Mover of Technology*. Bloomington, IL: McKnight & McKnight Publishing Co., Ch. 3., 1964.

Objectives

The student will

understand the conversion of thermal to mechanical energy; and
build a steam engine to demonstrate it.

Evaluation Focus

☐ Knowledge	☐ Problem Solving	☐ Attitude
☒ Awareness	☐ Machine/Tool Usage	

Building a Steam Turbine Engine

Procedure

In this activity, you will manufacture and operate the simple steam turbine engine. The activity demonstrates how thermal energy can be converted into mechanical energy.

1. Take a half pint or pint can (such as a paint can) and remove the lid. Turn the lid upside down on a piece of scrap lumber and punch a hole through its center with a hammer and a center punch.

2. Fill the can 1/4 to 1/3 full with water. Replace the lid tightly using a hammer.

3. Using a round piece of tin (such as a can lid), lay out eight equal sections as shown in Figure 1. With tin snips, cut approximately half way to the center on previously drawn guidelines. Bend sections over to form blades of a turbine wheel.

▶ Caution

The tin edges will be especially sharp. Take care not to cut yourself.

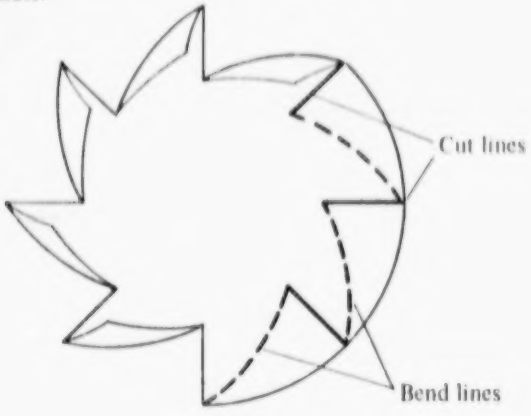


Figure 1

4. Nail the turbine wheel to a stick by driving a nail through the exact center. Check to make sure the wheel turns freely.

5. Place the can of water on a ring stand, and apply heat from a propane torch to the bottom of the can.

▶ Caution

Safety glasses should be worn.

The propane torch should be operated only with your instructor's permission and/or presence.

A fire extinguisher should be nearby whenever open flames are used.

6. Hold the turbine wheel over the steam escaping from the hole punched in the can top. Adjust the bends in the tin flaps or the distance from the hole until the wheel begins to turn.

▶ Caution

The can lid is the safety valve in this activity. If too much pressure builds up in the can, it could blow the lid off.

Keep your hands and face away from the top of the can.

7. Answer the questions on the Student Response Sheet.

Building a Steam Turbine Engine

Name _____

Class/Period _____

1. What energy conversion is taking place?

2. Is this an example of internal or external combustion? Explain your answer.

3. What type of motion/motions have you observed in this experiment?

(3B) Energy Conversion

Transportation

Hero's Steam Engine, an activity supporting the Technical Systems concept, is designed for approximately 3 class periods.

Resources Needed

Equipment

Propane torch
Drill press
Vise
Standard hand tools

Materials

Used carbon dioxide (CO_2) cartridge
Epoxy glue
#7 swivel (fishing tackle)
3/32" OD aluminum or brass tubing
(model plane gas line)
Thumb screw 1/4" (NC thread)
3/8" dowel pieces
Wire

Objectives

The student will

understand the conversion of thermal to mechanical energy; and
build a steam engine to demonstrate it.

Evaluation Focus

☐ Knowledge
☐ Awareness
☐ Problem Solving
☒ Machine/Tool Usage
☐ Attitude

Hero's Steam Engine

Procedure

In this activity, you will manufacture and operate the simple steam engine shown in the drawing. The activity demonstrates how thermal energy can be converted into mechanical energy.

1. Lay out, punch, and drill two holes in cartridge for tubing.
2. Center, punch, and drill hole in neck of tube.
3. Tap threads in neck of cartridge (use thread cutting oil).
4. Drill hole in thumb screw.
5. Put swivel eye and hook in thumb screw.
6. Lay out and cut two 1-1/2" pieces of tubing.
7. Bend both pieces of tubing nearly 90° near one end (use dowels to make a simple bending jig in the vise).
8. Pinch one end of tubing partly closed, and deburr the other end.
9. Insert deburred end of tubing into cartridge, and epoxy the connection. (**Note:** Do not get epoxy *in* the tubing.)
10. Blow through tubing to clear it.
11. Allow drying time for the glue.
12. Fill cartridge with water, and close top by putting thumbscrew in it.
13. Put a piece of wire in the bench vise to support your engine.
14. Hang engine on wire.
15. Operate engine by applying heat to bottom with a propane torch.

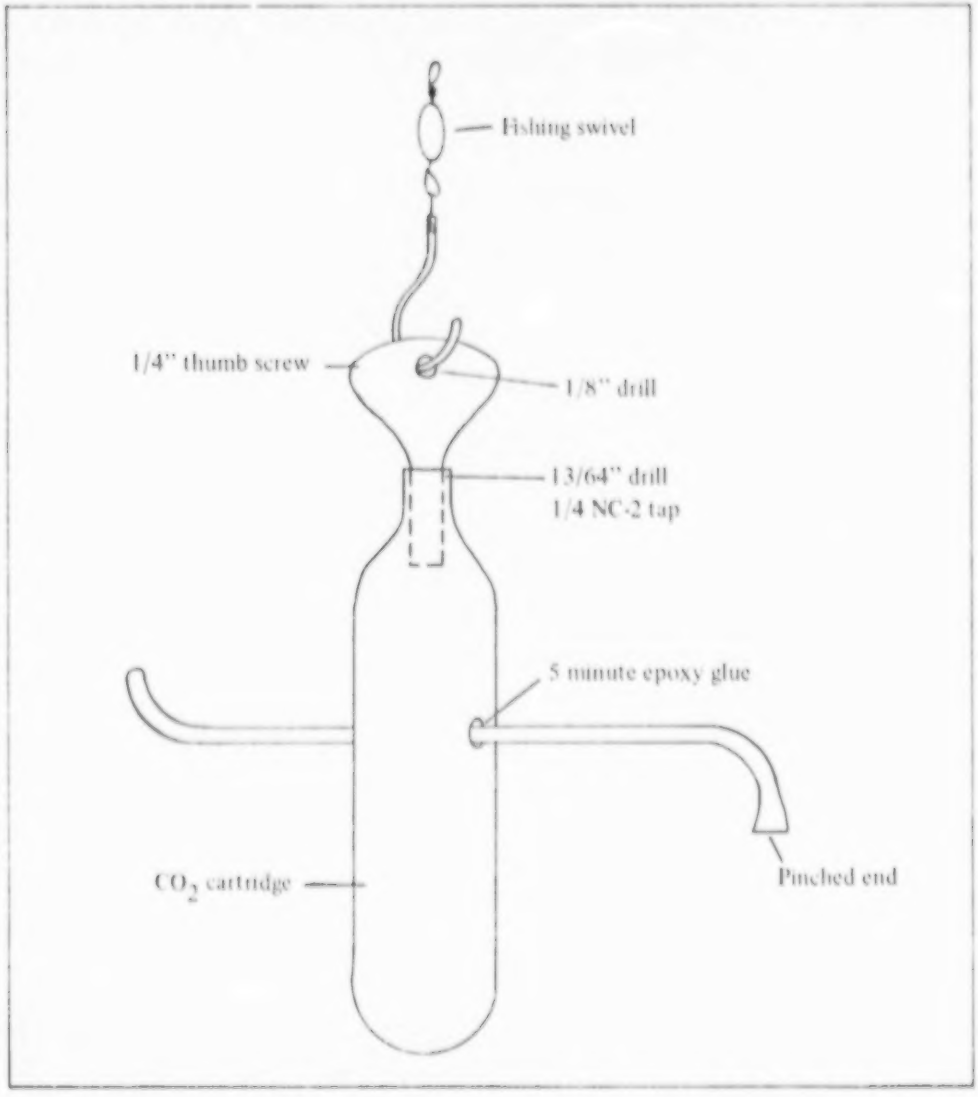
▶ Caution

Safety glasses should be worn.

The propane torch should be operated only with your instructor's permission and/or presence.

A fire extinguisher should be nearby whenever open flames are used.

Do not continue applying heat to the cartridge if the water has evaporated.


Fishing swivel
1/4" thumb screw
1/8" drill
13/64" drill
1/4 NC-2 tap
5 minute epoxy glue
CO_2 cartridge
Pinched end

(3B) Energy Conversion

Transportation

Transparent Engine, an activity supporting the Technical Systems concept, is designed for approximately 5 class periods.

Resources Needed

Equipment

Megatech transparent engine and manual available from
Megatech Corporation
Education Division
29 Cook Street
Billerica, MA 01866
Phone: (617) 273-1900

Film strip projector, screen, tape player

Materials

Filmstrips (available with the engine)

Introducing the Megatech Mark III Engine (MP2-AV1)
Effects of Fuel/Air Ratio and Manifold Pressure (MP2-AV8)
How to Measure Horsepower (MP2-AV4)

Objectives

The student will

understand the operating principles of a four-stroke engine;
successfully operate the Megatech transparent engine; and
conduct a series of experiments.

Evaluation Focus

[x] Knowledge	[x] Problem Solving	[ ] Attitude
[ ] Awareness	[x] Machine/Tool Usage	

Transparent Engine

Procedure

Many unique features are incorporated into the Mark III transparent engine to make it an excellent research and teaching tool. Since this engine is designed with most of its functional parts exposed, it is easier to see the interrelationship of components and how mechanical energy is produced. The engine will help you understand the basic principles of combustion engines.

You will be learning about and working with this engine for the next five class periods or so. Each day you will be expected to be able to answer the questions given on the Student Response Sheets. The answers will come from a combination of your reading, viewing filmstrips, and conducting some hands-on experiments with the engine, as directed.

▶ Caution

The engine should be operated only with your instructor's permission and/or presence.

The engine should not run for more than ten minutes at a time. Excessive heat build-up could crack the cylinder.

Day One

1. View filmstrip (with tape) *Introducing the Megatech Mark III Engine.*

2. Read activity MP2-JM1, "Learning the Parts of a 4-Cycle Engine," in the engine manual.

3. Answer the questions for Day One on the Student Response Sheet.

Day Two

1. Read activity MP2-JM7, "Starting the Mark III Engine."

2. Start the engine, carefully following the directions in the manual.

3. Answer the questions for Day Two on the Student Response Sheet.

Day Three

1. View the filmstrip (with tape) *Effects of Fuel/Air Ratio and Manifold Pressure.*

2. Since the engine is a device for harnessing chemical energy released in the combustion process, the amount of fuel added before combustion has a strong influence on the engine performance. The rate of flow of fuel into the engine divided by the rate of flow of air into the engine is called the *fuel/air ratio.* When the value of this ratio is between certain limits, combustion is possible. These limits are called the *limits of flammability.* The middle of the range is the best mixture of fuel and air. There, just enough fuel is present to completely react with oxygen from the air. This is called the *stoichiometric ratio.*

Start the engine as outlined in Chapter III, Section A of the manual, and adjust the fuel needle valve for smoothest operation. Run the engine three to four minutes to warm up. Run engine at half throttle open position. Now observe the color of the flame. Close the needle valve until the engine just barely runs, and observe the color of the flame. Open the needle valve again until the engine smooths out, and continue opening until the engine again runs roughly. Varying the amount of fuel in the cylinder makes the mixture either rich or lean.

3. Complete the learning activity in the manual.

4. Answer the questions for Day Three on the Student Response Sheet.

Day Four

Under load and with a certain percentage of water injection, the horsepower of an engine can be increased. It sounds strange that a liquid, which is not a fuel, will increase the horsepower. While the physics of combustion theory is very difficult to understand, the gross effects of the combustion can be observed. More research has to be done before we can better understand why water increases the horsepower level. At present, two possible reasons are given.

A. Water injection adds more mass to the fuel and air that cause the combustion, and the additional mass is converted into momentum (pressure on the piston), thereby generating more horsepower.

B. Water molecules break down into H_2O_2, and the O_2 enhances the combustion process. (Not much evidence is available on this possibility.)

The Megatech Mark III is designed with a secondary fuel line and a tank so it can be used for water-injection experiments. To perform the experiments, any fuel can be used.

1. Fill one tank with tap water and the other with alcohol.

2. Start the engine with only the fuel on, and let it warm up for three to four minutes.

3. Open the throttle valve three-fourths turn to full position. If the color of flame indicates a rich mixture, adjust the fuel to get a blue color.

4. Now open the water valve one turn. Wait until you see that the water line is full. (It might be necessary to choke the engine for a second to pull the water from the tank to the needle valve.)

5. Increase and decrease the amount of water released, and notice the color (bright orange) when water is injected. Observe any change in the performance of the engine.

6. Change the fuel to gasoline and repeat the steps above. (You can try any number of fuels or any combination.)

7. Complete activity MP2-JM11, "Water Injection Equipment," from the manual.

8. Answer the questions for Day Four on the Student Response Sheet.

Day Five

Fuel/air ratio is not the only thing that influences engine performance. The mixture must also be ignited at the correct time to permit combustion to do the most work on the piston. Ignition timing is usually described as the piston being several degrees before or after "top dead center." If the spark plug fires the instant the piston is at "top dead center," (the highest point the piston reaches), the timing is described as being at "zero degrees."

When the flywheel makes one complete revolution, it goes through 360 degrees. In the normal direction of rotation, there is a correlation of piston motion with the point on the flywheel (in front of the arrow) and the flywheel plastic cover markings. When the point on the flywheel reads zero degrees on the plastic cover, and the spark plug fires exactly when the piston is on top, then it is said "the timing is zero degrees."

You can study the effect of ignition timing on engine performance in two steps. In the first step, the firing of the spark should be studied with the fuel off but the electrical power on, so that the firing of the spark can be observed through the cylinder wall. The rotation of the engine is done manually.

1. Connect the power source to terminals of the engine.

2. Turn the switch on, but do not open the fuel.

3. Move the timing lever as far up as you can.

4. Manually rotate the flywheel in the direction of the arrow shown on it. Start with the intake stroke.

5. Proceed slowly with the second stroke, the compression, and carefully watch the spark plug fire. As soon as it fires, immediately stop rotating the engine flywheel.

6. On the plastic cover, read the degrees before "top dead center" where the spark plug fired. (Note the position of the point in front of the flywheel in relation to the markings on the plastic cover.)

7. Now lower the timing lever as far as possible (to its most retarded position).

8. Repeat Steps 4 and 5.

9. Note how the piston passed dead center and then the spark plug fired.

In the second step, the engine is run with the fuel on. As it runs, the timing lever is advanced or retarded.

10. Start the engine and let it warm up for a few minutes with the throttle setting half open.

11. Set the fuel/air mixture slightly on the rich side.

12. Start lowering the lever to retard the timing and notice the engine speed drop and the flame look longer.

13. Advance the timing lever all the way. Note the flame length getting shorter and the engine speed (rpm) increasing.

14. Move the lever back to the halfway position (top dead center) at zero degrees. Note the speed in comparison to the advanced or retarded position.

15. Answer the first four questions for Day Five on the Student Response Sheet.

16. View the filmstrip (with tape) *How to Measure Horsepower*.

17. Complete activity MP2-JM-2, "How to Measure Horsepower," from the manual.

18. Answer Questions 5 through 9 for Day Five on the Student Response Sheet.

Transparent Engine

Name _____

Class/Period _____

Day One

1. What is the purpose of the carburetor?

2. What parts make the spark in a four-cycle engine?

3. What is the purpose of the rocker arms?

4. What causes the crankshaft to rotate?

5. What is the difference between the needle valve and the throttle?

6. What do piston rings do?

7. What is the crankshaft journal?

8. What does the camshaft do?

9. What causes the spark plug to fire at the right time?

10. What is the purpose of the flywheel?

Day Two

1. After you have the engine running smoothly and as fast as possible, close the needle valve and record the slowest speed you can get without the engine stopping. Do not adjust the throttle.

2. Bring the engine back to operating speed, and then close the throttle slowly. Record the slowest speed you can attain without stopping the engine. Do not adjust the needle valve.

3. Bring the engine back to operating speed and then, using both the throttle and needle valve, see how slowly you can get the engine to run without stopping.

4. In each of the above situations, what is the color of the flame at the slowest speed?

5. Why is a tachometer useful when tuning an engine?

Day Three

1. Can you guess why the flame with the mixture too rich (needle valve too far open) has a very yellow color and why the too-lean mixture produces a blue to almost-clear color? **Note:** If the fuel contains traces of sodium or other foreign matter, a clear or blue flame may not be observed.

2. Did you notice the engine speed up as you changed the fuel/air mixture ratio? Do you get a higher speed with lean (blue flame) or rich (yellow flame) mixture?

3. What color is the flame when the engine is running poorly?

4. Under what conditions did the flame turn yellow?

5. According to the tachometer, what type of mixture produced a higher speed?

6. What color was the flame with a lean mixture?

7. What color was the flame with a rich mixture?

8. How would fuel/air ratio affect mileage in a car?

Day Four

1. Can you inject water into any fuel?

2. Do you notice the engine speed changes with the amount of water being injected?

3. Do you know why the water causes a bright orange color?

4. What was the color of the flame before the water was injected?

5. After the water was injected, what did the engine speed do?

6. What was the slowest speed at which the engine would run with the maximum amount of water injected?

7. Why would anyone want to use water injection?

Day Five

Questions on Timing

1. At 20 degrees advanced position, approximately how far down is the piston from "top dead center" (1/8, 1/4, or 1 inch)?

2. Why does the flame seem shorter in the advanced position?

3. At what approximate lever position does the engine seem to run faster?

4. Do you know why the retarded position gives lower speed?

Questions on Horsepower

5. Determine engine torque and calculate horsepower for the given engine rpm's.

Engine rpm	Engine Torque	Horsepower (calculated)
1800		
2000		
2200		
2400		
2600		

6. What is the formula for horsepower?

7. What is a dynamometer?

8. At what speed do you get the most power?

9. Does maximum torque mean maximum power?

(3C) Propulsion Systems

Transportation

Compressed Air Propulsion, an activity supporting the Technical Systems concept, is designed for approximately 5 class periods.

Resources Needed

Materials
Balloons

Objectives

The student will
understand principles of propulsion;
design and construct a vehicle using compressed air as its energy source; and
demonstrate the vehicle.

Evaluation Focus

☐ Knowledge	☒ Problem Solving	☐ Attitude
☐ Awareness	☐ Machine/Tool Usage	

Compressed Air Propulsion

Procedure

Much recent attention has been given to alternate sources of power, fuel, and energy. Many new inventions are available that claim to use small amounts of energy or fuel and to be low in harmful emissions. Many of these "new" ideas, however, are simply old ideas that are redesigned or renamed. You are going to design and build a vehicle using a power source that is very old, but which has always been nonpolluting.

Specifically, design a vehicle that will operate using compressed air as an energy source. The container for the compressed air will be a large balloon.

Design Considerations

Before you begin, determine whether there should be common specifications for each design.

1. Should the vehicle be designed to travel the greatest distance or to attain the greatest speed over a given distance?

2. Should a maximum weight (in ounces) and/or size (in cubic inches) range be specified?

3. Should the vehicle travel by land, water, air, or any combination of these?

4. Should the compressed air act directly against the atmosphere (reactive propulsion) or against another mechanism to drive the vehicle? Is either all right?

5. Can more than one balloon be used?

(3C) Propulsion Systems

Transportation

Marine/Terrestrial Vehicle, an activity supporting the Technical Systems concept, is designed for approximately 1 or 2 class periods.

Resources Needed

Equipment

Capsella kits, available from
Creative Learning Systems
Science and Technology Division
936 C Street
San Diego, CA 92101

Materials

Plywood for ramp and platform

Objectives

The student will

learn about vehicle propulsion systems;
design and construct a vehicle that will travel on land and water; and
demonstrate the vehicle.

Evaluation Focus

☐ Knowledge	☒ Problem Solving	☐ Attitude
☐ Awareness	☐ Machine/Tool Usage	

Marine/Terrestrial Vehicle

Procedure

Human beings have been very adept at designing vehicles that move in either water, air, a vacuum, or on land. It is more difficult to design a vehicle that easily propels itself through more than one of these mediums. It can be done, however. Military organizations, for example, have developed many such vehicles for specialty transportation needs. Your task will be to design and build a vehicle that will propel itself through water and on land.

Design Problem

Capsella kits provide directions for assembling several land vehicles and several marine vehicles. The object of this activity is to synthesize a new design to create a vehicle that will travel on both land and water.

Using the Capsella components, construct an amphibious vehicle that will propel itself a distance of three feet in water, climb a ramp, and propel itself three feet on a smooth, hard surface. Remember the motor and electrical control must be above water level.

You will need to construct a short ramp and platform of plywood.

(3C) Propulsion Systems

Transportation

Mousetrap Vehicle, an activity supporting the Technical Systems concept, is designed for approximately 6 class periods.

Resources Needed

Materials
Mousetraps

Objectives

The student will
learn how a mechanical device transmits energy;
design and construct a propulsion system in response to a given problem; and
demonstrate the system.

Evaluation Focus

- ☒ Knowledge
- ☐ Awareness
- ☒ Problem Solving
- ☐ Machine/Tool Usage
- ☐ Attitude

Mousetrap Vehicle

Procedure

If you have ever had your finger caught in a mousetrap, you realize the potential power of the spring! It releases a great amount of force and torque in a very short span of time. Since the beginning of time, man has used the spring as a useful tool to do many tasks for him.

You are going to become an inventor. Using a standard size mousetrap, construct and test a terrestrial vehicle using the mousetrap as the propulsion device. You will have to be concerned with the control and guidance systems of this terrestrial vehicle. Obviously the structural and suspension systems also will play an important role.

There are many questions you should consider before you begin designing your vehicle.

1. What material and size wheels should be used?

2. What about traction?

3. What about friction?

4. Should you lengthen or shorten the flipper arm?

5. How can you transfer power for propulsion?

6. Which is more important for propulsion release, speed or torque?

7. What is momentum, and how can you use it effectively to extend potential power?

Design Considerations

1. Use only standard mousetraps.

2. Only one 180-degree swing of the mousetrap flipper may be used for propulsion.

3. You may extend or shorten the flipper.

4. You may use any materials you wish in construction.

5. Judging will be by distance and straightness of the vehicle's linear travel.

6. Competition consists of two tries, with the best one used for grading.

Mousetrap Vehicle

Name _____

Class/Period _____

1. Define "torque."

2. Give the formula for determining torque. T = _____ x _____

3. If the force, measured by a spring scale, is 20 ounces on the flipper of the mousetrap, and the flipper length is 2.5 inches, what is the resulting torque? (Show your work.)

4. Do we always get more torque as we increase the length of the flipper arm? If the torque increases, what happens to the speed?

5. Define "momentum" and explain how this could improve the distance your mousetrap vehicle traveled?

6. What role(s) did friction play in your mousetrap vehicle?

7. Give an example of each system component you used in your vehicle.

   control:

   guidance:

   propulsion:

   structural:

   suspension:

8. Give two examples of future terrestrial transportation vehicles.

(3E) Control Systems

Transportation

Designing for Safety, an activity supporting the Technical Systems concept, is designed for approximately 2 class periods.

Resources Needed

Materials

Raw eggs
Crash test vehicles
Plywood or masonite ramp
Concrete block
Assorted springs, rubber bands, styrofoam, sponges, weather stripping, balloons, etc., for constructing safety devices
Plastic bags and sheets

Objectives

The student will

learn about the effects of design on vehicle safety;
design safe methods of absorbing energy; and
test their designs.

Instructor's Options

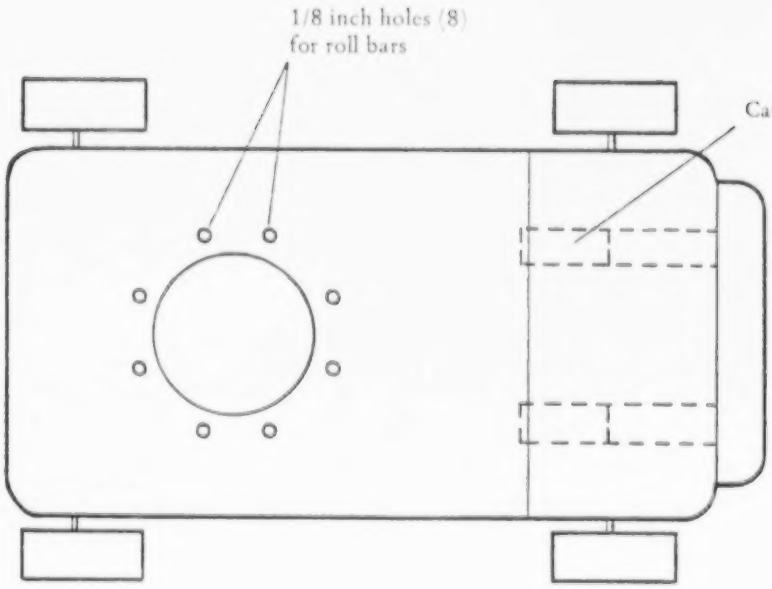
A vehicle design is included so that students can construct the crash test vehicles, if desired. Also, students could videotape the test crashes for replay in slow motion. A short safety video could be made for driver education courses.

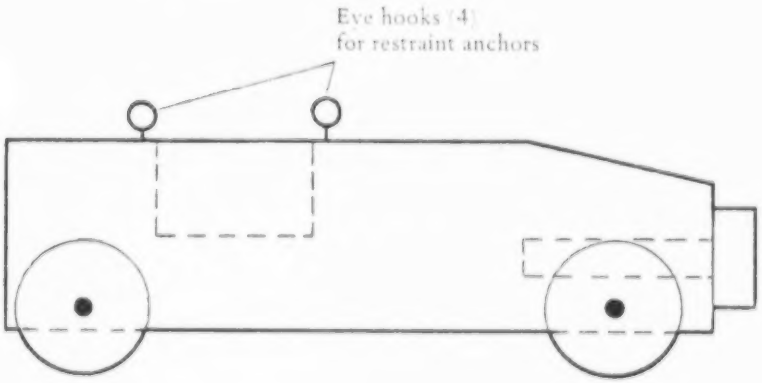
Evaluation Focus

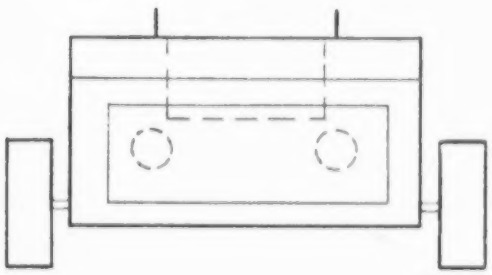
- [x] Knowledge
- [ ] Awareness
- [x] Problem Solving
- [ ] Machine/Tool Usage
- [ ] Attitude

Designing for Safety

Crash Test Vehicle Plan







Crash Vehicle

Material list
- One 2x4x9 block
- Two 3/8 dowels
- Four wheels 1-1 1/2 inches
- Four small eye hooks

Assorted
- Springs
- Balloons
- Rubber bands
- Weather stripping

Designing for Safety

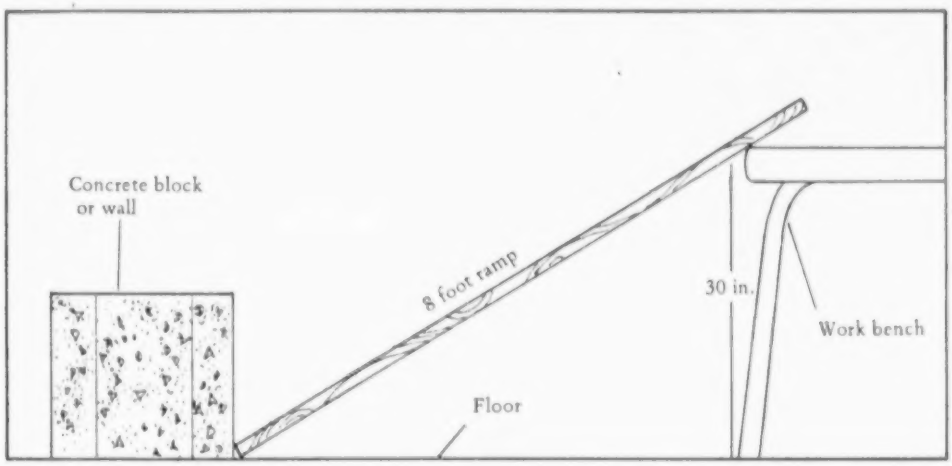
Procedure

The purpose of this activity is to experiment with various passenger restraint devices and vehicle safety features, items which have become prevalent in today's automotive industry. Since automobile accidents account for such a large number of deaths and serious injuries each year, safety feature design has become a major part of the auto industry. This activity asks you to assume the role of a safety engineer.

Design Problem

Design and install safety devices on the test vehicle so that when it is rolled down an eight-foot ramp into an immovable object, the passenger (egg) will be protected from injury during the resulting "crash." You may add to the test vehicle, but you may not modify the basic structure.

1. Set up your crash test ramp according to the diagram.



Place an egg in a plastic bag (to control mess) and place it in the passenger compartment of the crash test vehicle. Roll the vehicle down the ramp. Describe what happened when the vehicle struck the immovable object—use the lines at Item 1 on the Student Response Sheet.

2. Identify various devices that would help protect the passenger, and list them at Item 2 on the Student Response Sheet.

3. At Item 3 on the Student Response Sheet, classify the devices on your list as either "restraint" or "energy-absorbing" devices.

4. Modify your test vehicle to include some of your safety devices. Retest the vehicle. At Item 4 on the Student Response Sheet, explain which devices seemed to offer the most protection.

5. Continue to refine your vehicle until it can sustain three consecutive tests without damage to the egg. (A crack constitutes damage.)

Design Conclusions

6. Based on your observations and design experiments, write a conclusion statement summarizing your findings. Use Item 5 on the Student Response Sheet for your answer.

Designing for Safety

Name _____

Class/Period _____

1. What happened to the vehicle?

   the "passenger"?

   the "wall"?

2. List possible safety devices.

3. Classify them.

Restraint	Energy Absorbing

4. List effective safety devices.

5. State your design conclusions.

(3F) Guidance Systems

Transportation

Infernal Machine, an activity supporting the Technical Systems concepts, is designed for approximately 4 class periods.

Resources Needed

Equipment

Fire extinguisher
Stopwatch

Materials

5/8" steel ball
Wooden matches

Suggested References

Gourley, Theodore J., and C. Samuel Micklus. *Problems to Develop Creativity*. Glassboro, NJ: Creative Competitions, Inc., 1984.

Gourley, Theodore J., and C. Samuel Micklus. *Problems! Problems! Problems!* Glassboro, NJ: Creative Competitions, Inc., 1984.

Both available from
Creative Competitions, Inc.
P.O. Box 27
Glassboro, NJ 08028

Objectives

The student will

learn about a vehicle guidance system;
design and construct a guidance system in response to a given problem; and
demonstrate the system.

Evaluation Focus

☒ Knowledge	☒ Problem Solving	☐ Attitude
☐ Awareness	☐ Machine/Tool Usage	

Infernal Machine

Procedure

Given a steel ball (ball bearing) five-eights of an inch in diameter, design a device that will keep this ball in motion for precisely ten seconds. At the end of the ten seconds, the ball, or some process activated by the ball, should light a wooden match.

▶ Caution

A fire extinguisher must be at hand whenever you practice with or demonstrate your device.

Design Considerations

1. The device must be self-contained and fit within four cubic feet of volume.
2. There are no restrictions on material.
3. No explosive or potentially dangerous devices may be used to ignite the match.
4. The ball must stay in motion for exactly ten seconds.
5. The match must light.
6. The solution should be creative and unusual.
7. The workmanship should be of high quality.

Example

One imaginative solution used a funnel supported on one side by a spring and on the other side by a balloon filled with air. The steel ball, released by a pinball spring, whirled interminably in the funnel. At the same time the ball was released, a water column began to descend a small pipe marked off in seconds. After rounding a bend, the water began to rise, still under pressure, floating a small cork fixed with a pin, its point projecting upward directly beneath the balloon. At precisely ten seconds, the balloon popped, upsetting the balanced funnel and dropping the steel ball directly onto a mousetrap. As the mousetrap sprang open, it forced a wooden match against an overhead piece of emery paper, thereby igniting the match.

(3G) Structural Systems

Transportation

Wind Vehicle, an activity supporting the Technical Systems concept, is designed for approximately 5 class periods.

Resources Needed

Equipment

21" fan
Common tools (hammers, saws, files, drills)
Common drawing tools (straight edge, ruler, graph paper)

Materials

1	Block of either foam plastic or wood, 1-1/2" x 3-1/4" x 9"
4	1/2" x 1-3/8" diameter wooden wheels bored with 17/64" axle hole
4	1/4" push nuts
15	15" (or less) of 1/4" birch dowel rod (student to specify the exact amount needed)
4	Common nails, 4d
1	Piece of 3" x 3" cardboard
1	Square each of coarse, medium, and fine sandpaper
1	1" of 1/4" thick wall plastic tubing for wheel spacers
1	8" or less of 1/2" x 1/2" pine for mounting axles
1	Single-edged razor blade
4	Washers for wheel spacers
	String
	Miscellaneous paints, brushes, decals
	Masking tape
	Epoxy glue
	Beeswax for lubrication
	Oil for lubrication
	Polyvinyl, white glue

Special Notes

Foam bodies can be cut from 1-1/2" insulation foam sheets that can be purchased at local lumber yards.

Wood, the alternative body choice, can be cut from stud-grade 2" x 4"s available from local yards or salvaged from scrap at building sites.

Wooden wheels may be made with a 1/4" axle hole using a 1-3/8" hole saw (available from Brodhead-Garrett, 4560 E. 71st Street, Cleveland, OH 44105: No. 586305, adjustable dial saw, model 4516, 1987 price—$7.15 each).

Students using nails to fasten their wheels will need wheels with a 1/8" axle hole. Since these wheels are expensive, the instructor may wish to reclaim them after the exercise if they are used (available from Industrial Arts Supply Company, 5724 W. 36th Street, Minneapolis, MN 55416: G300-261, P wheel, 1/8" axle hole, 1-5/8" diameter, 1987 price—$13.95 per 100; or Woodcraft, 41 Atlantic Avenue, Box 4000, Woburn, MA 01888: 50N23-PJ, 1-1/2" diameter x 3/8" x 1/8" axle hole, 1987 price—$10.95 per 96).

For spacers to keep wheels away from the body, either 1/4" washers, or from Brodhead-Garrett, 306436, 3/8" OD, 1/4" ID, 1/16" thick polyethylene tubing (1987 price—$0.15 per foot) may be used.

Objectives

The student will

learn to use wind as a propulsion system;
consider the effects of wind resistance, friction, and weight on vehicle design;
design and build a wind-powered vehicle; and
test the vehicle.

Evaluation Focus

- ☐ Knowledge
- ☐ Awareness
- ☒ Problem Solving
- ☒ Machine/Tool Usage
- ☐ Attitude

Wind Vehicle

Introduction

Our forefathers were much better conservationists than we are today. This may be because they had so little that they had to make everything go farther.

America's past wastefulness was obvious in the late 1970's as some of our resources, especially oil, began to become scarce. The oil shortage made it apparent that, as the largest oil-consuming nation in the world, we would need to learn conservation techniques. Our conservation of oil took many forms. We turned to other sources for energy, such as coal. We cut down on the use of our oil-consuming devices. We used our cars less, shared rides, and started to redesign our vehicles for greater efficiency. The redesign of our vehicles has probably produced most of the fuel savings our country achieved.

Conservation of energy through design is almost as old as conservation itself. Picture the early water-born transportation vehicles. Those sleek, trim sailing ships were not designed that way for appearance alone. They were meant to slice through the water with the least amount of resistance. Even the canoe sacrifices a lot of stability and convenience that could have been achieved with a square bow and flat bottom. The canoe's design permits it to navigate streams with considerably less resistance and, therefore, less work. Where do you see energy conservation in our early transportation. Did the design of early wheeled vehicles conserve energy?

Cars are designed by professionals, usually automotive engineers, whose training and experience enable them to bring together the needs of appearance, function, and efficiency and to mold these elements into the cars of today and the future. The designer is assisted in this work by many other workers. Drafters, for example, convert sketches, notes, and drawings into an organized set of plans for production. Today, both drafters and engineers use computers to perform routine design tasks. Technicians also are part of the design team. The role of the technician is often that of a "go between," bringing the ideas of the designers and engineers to those who must implement the ideas. Technicians must be knowledgeable in both design and manufacturing skills. The design team also includes model makers who use

woodworking and ceramic- and plastic-shaping skills to prepare the first three-dimensional expression of a design. (Many others are also involved in designing cars. Ask your instructor for help in finding out more about jobs in this interesting field of work.)

For this activity, you are going to become the designer, drafter, and model maker of a wheeled, wind-powered vehicle. You will also be the test driver.

The efficiency of your vehicle will depend on how well you design it, using the limited information contained in this packet. Efficiency of your design will be measured by the distance your vehicle travels during the test at the Big Windy Rally, which will be held on the last day of this activity.

Design Considerations

In designing your vehicle, there are many factors you should keep in mind that will affect your vehicle's performance. Four that are especially important are discussed in this section.

Catching the Wind

Wind can be captured behind a large mass, and its force used to propel a wheeled vehicle. A concave-shaped surface will capture more wind force than other shapes before allowing wind to escape around the outside of the mass. Is this why a sail becomes more efficient as it balloons out? The picture of the sail in Figure 1 is a good example of a concave shape.

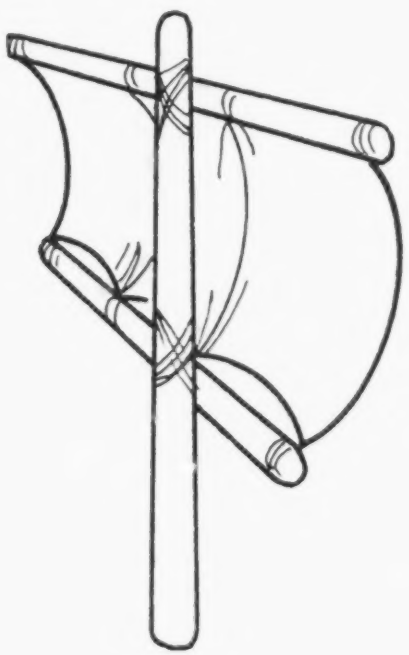
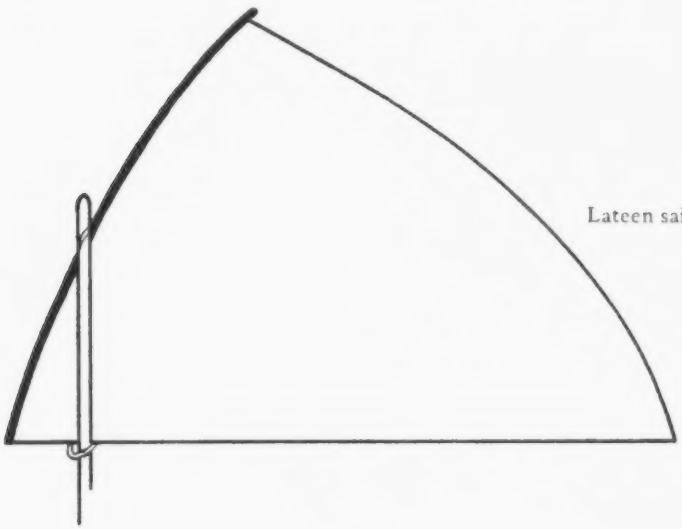
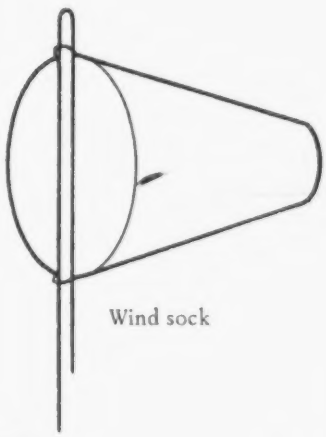


Figure 1

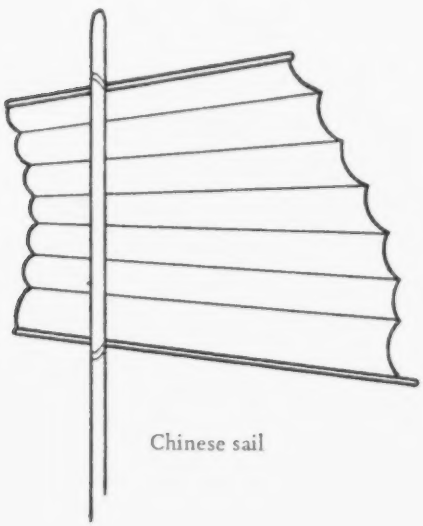
Other types of wind catchers and sails have been used in other places and cultures depending upon their purpose.



Lateen sail



Wind sock



Chinese sail

Hawaiian sail

Wind Resistance

The sail or mass will encounter resistance in pushing air out of the way as it moves forward. A convex surface reduces this resistance by allowing air to more easily pass over it (see Figure 2). Would a different shape be even better? (If you want to know more about air and resistance, look under "aerodynamics" in the card catalog in your library.)

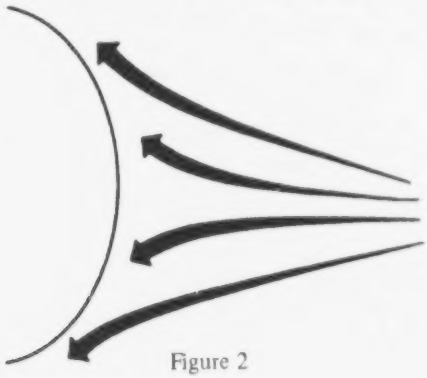


Figure 2

Friction

The reduction of friction is an age-old problem, and it should not be overlooked in your design. Energy is wastefully used when one or more moving surfaces lose motion by coming in contact with a surface that is not moving, moving at a slower rate, or moving in an opposite direction. Friction can be reduced both by lubrication and design. Methods of reducing friction through design include reducing the amount of surface contact. For example, an oval tire will create less friction than a flat tire (see Figure 3). Also, the hole you designed for the wheel should be large enough to allow the wheel to spin freely around the axle holding the wheel in place. Don't, however, make it so loose that it toes (or points) in or out (see Figure 4). If your wheels rub against the side of your car, energy will be lost to friction. In Figure 5, which axle arrangement, A or B, will give the least amount of friction?

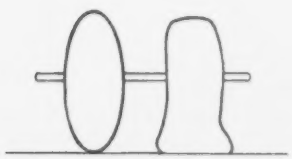


Figure 3

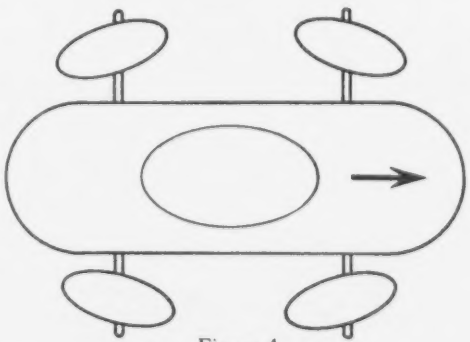


Figure 4

Lubrication, of course, can also help reduce friction. If parts must move against each other, keeping them well lubricated with oil or grease reduces friction a great deal.

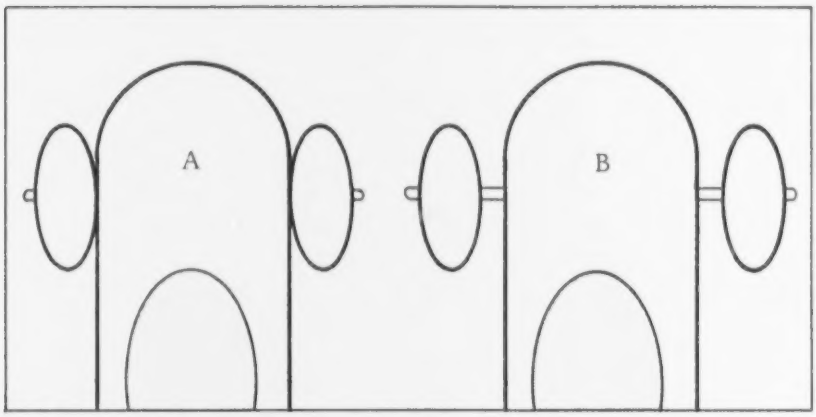


Figure 5

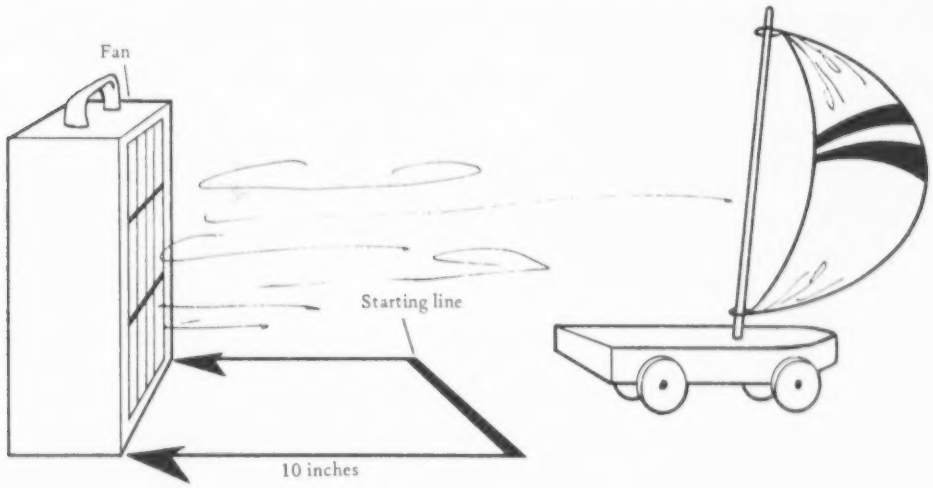
Weight

Weight can decrease the efficiency of wheeled vehicles because of the increased friction it causes on the moving parts. However, weight can also have an advantage called "momentum." That is, once an object has been propelled, weight can cause it to go farther if all other factors are equal. Too much weight, however, will affect speed and friction. This is one of the design problems you will have to solve.

The source of power for the Big Windy Rally will be a stationary electric fan. The fan will exert its greatest force at the start of the race course and will lessen its force at the end of the race course. Keep that thought in mind, too, as you carefully select the design and materials for your vehicle.

Limits and Specifications

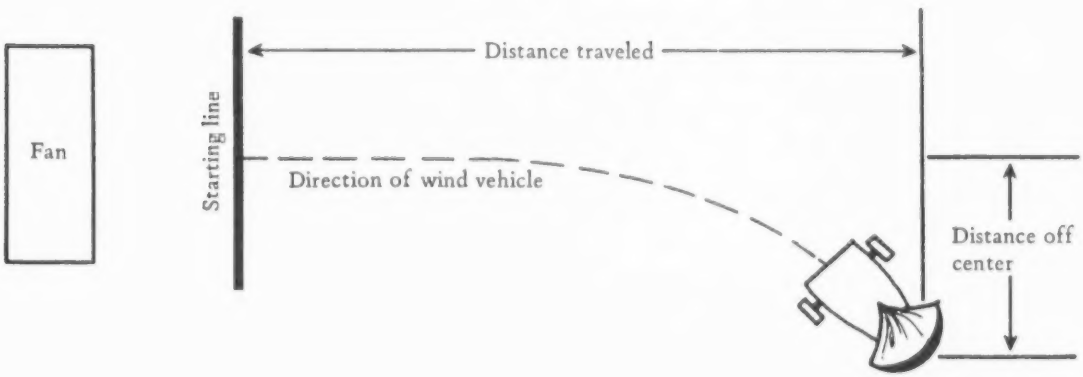
1. The only source of energy that may be used to propel the vehicle will be air produced by a 21", household-type fan that will be positioned behind the starting line.



2. The vehicle must start from a dead stop *behind the starting line*.

3. The maximum size allowed for each vehicle will be 5" wide, 8" high, and 10" long.

4. The distance traveled will be measured from the starting line to the front of the vehicle *minus the distance that the vehicle travels off center*. One point per centimeter traveled will be awarded.



5. A maximum of two trials to be completed in no more than four minutes will be allowed.

6. The cost of the materials supplied by the student may not exceed $0.50. The cost of materials supplied by the school are not counted.

Construction Tips

How to Fasten Your Wheels

Wheels can be fastened to your vehicle in several ways. Three methods will be shown here, using dowel rods, wire, and nails (nails do not work well in fastening wheels to foam bodies). You may choose one of these methods or devise your own. Also, you have a choice of fastening your wheels directly to the body, as in Figure 6, or first fastening the wheels to axle stock and then attaching the axle stock to the body, as in Figures 7 and 8.

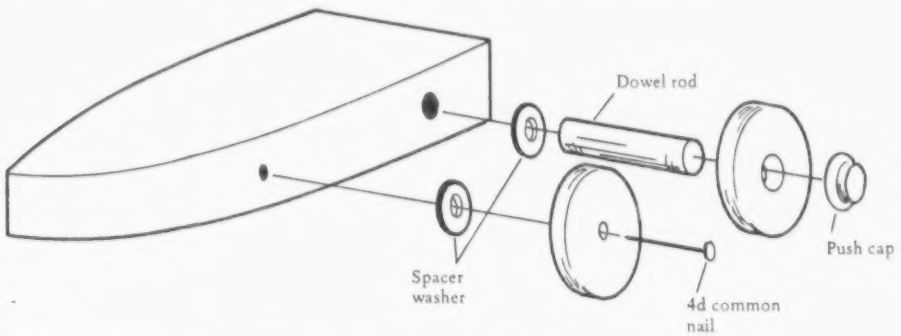


Figure 6 Wheels attached directly to the vehicle body

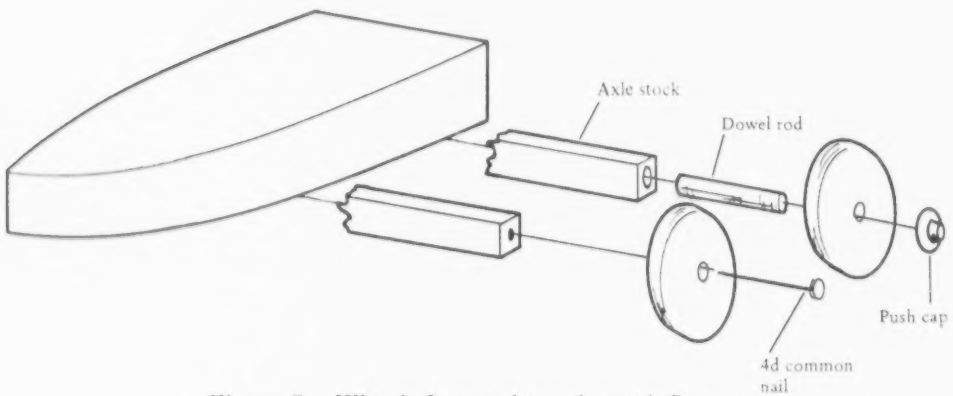


Figure 7 Wheels fastened to axle stock first

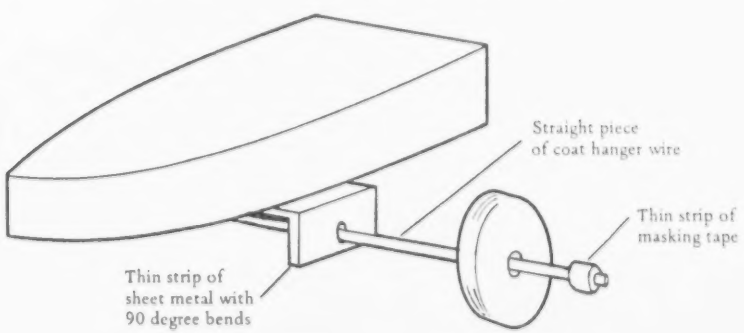


Figure 8 Wheels fastened to axle stock first

Daily Procedure

First Day

Your tasks

1. Study the design information material.
2. Start to design an efficient, wind-propelled, wheeled vehicle. You should make sketches and notes of your ideas. Your design will be limited by materials. You may use any of your own materials, but you may not spend more than $0.50 on them, or you may select materials from "school stores."
3. Save your sketches and notes as evidence of your hard work. They will be part of your grade.

You may need

Information packet
Pencil and paper
Basic drawing equipment (straight edge, ruler, graph paper)
Evaluation sheet

Second Day

Your tasks

1. Complete the design sketches and make a drawing of the side view and the rear view. You may find it helpful to also draw a top and front view. Keep in mind that you have only one day to draw.
2. Make a complete list of required materials you will need to make your wind vehicle.

You may need

Graph paper
Basic drawing equipment
School stores list

Third Day

Your tasks

1. Get your materials.
2. Start construction. Begin with subassemblies that may have to be glued together before attaching them to the body.

You may need

Your materials
Saws
Abrading equipment such as files, rasps, and sandpaper
Glue
Drills
Books on construction skills

Fourth Day

Your tasks

1. Complete construction.
2. Paint subassemblies and/or the complete unit.
3. Assemble.
4. If you complete your vehicle early, you may test your design and make adjustments (to minimize friction), lubricate, or add or reduce weight.

You may need

Can of spray paint or paint and brushes
Hammer and nails

Fifth Day

Your tasks

1. Complete assembly.
2. Complete appearance modifications (touch up paint, apply decals, etc.) if there is time.
3. Make adjustments to maximize wind propulsion.
4. Road test vehicle in the Big Windy Rally.

You may need

Vehicle test station
Student Response Sheet (to record distance)

Wind Vehicle

Name _____

Class/Period _____

1. Check that you have all items to be turned in.

   - ☐ Sketches of your proposed solutions (side view, rear view)
   - ☐ Finished drawing of your vehicle (side view, rear view)
   - ☐ This sheet
   - ☐ Completed wind vehicle

2. Name of vehicle _____

3. Cost of vehicle (do not count school supplies): $_____

4. Size of vehicle: _____ x _____ x _____
   (width) (height) (length)

5. Distance traveled first try _____ (in cm) *minus* distance off center _____ *equals* _____ total distance.

6. Distance traveled second try _____ (in cm) *minus* distance off center _____ *equals* _____ total distance.